CHAPTER 2. VEGETATION AND SOIL STABILIZATION CONTROL MEASURES

2.1 GRASS CHANNELS

Figure 2.1. Stream channel (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Overview

Description: An excavated drainageway to convey runoff through, along, or around the area to be protected; the channel is lined with vegetation to stabilize the surface from erosion. For additional information, refer to Vegetated Channels in Section 1.6.

Problem identification: Water runoff must be conveyed across the construction site while retaining sediment that enters or is collected onsite.

Design purpose: To convey runoff across the construction site while reducing water velocity and allowing for sediment collection.

Associated practices: Used with sediment trapping device if sediment-laden runoff is being diverted; also used with berms and diversions.

Installation: When temporary channel grades are steeper than 2.5% to 3.0%, some type of protection is needed to prevent erosion. Depending on the grade, some of the following protective ditch liners can be used: asphalt, burlap, concrete, excelsior, fiberglass, grass, jute, nylon, plastic sheeting, riprap, and sod. The manufacturers normally include specifications to

indicate the velocities and grades that the product will tolerate. For permanent waterways over 0.005 grade, ditch protection may be needed.

Flow should not exceed four fps.

The waterway and outlet shall be shaped to grade with a uniform cross-section. The waterway shall be stabilized with seed, fertilizer and mulching. Vegetative linings vary in the protection afforded. Erosion in the channel bottom should be graded or corrected to the original grade and covered with a ditch liner, excelsior, sod, or other appropriate material.

Maintenance/inspection: Inspect after each precipitation event.

Design life: Permanent.

Estimated cost: Usually bid as square (100 sq ft): grass range is $9.80 to $35.00 (2004) and riprap is $32.00 per ton (2004).

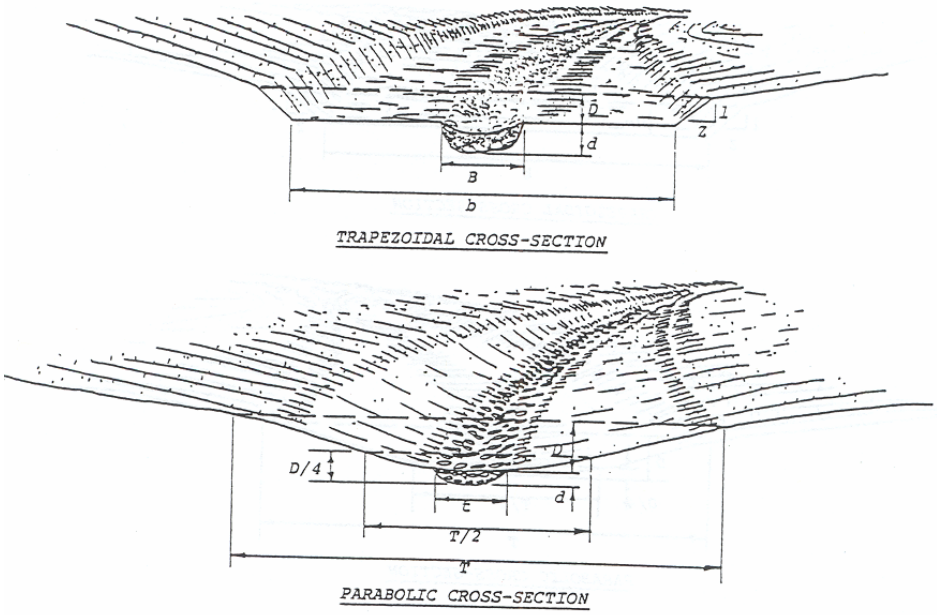

Figure 2.2. Waterway cross section (Source: Omaha Soil Erosion Manual)

Construction Specifications

1. All trees, stumps, obstructions, and other objectionable material shall be removed and disposed of so as not to interfere with the proper functioning of the waterway.
2. The waterway shall be excavated or shaped to the line, grade, and cross section as required to meet the criteria specified herein and be free of bank projections or other irregularities that will impede normal flow.
3. Fills shall be compacted as needed to prevent unequal settlement that would cause damage in the complete waterway.
4. All earth removed and not needed in construction shall be spread or disposed of so that it will not interfere with the functioning of the waterway.

5. Stabilization shall be done according to the appropriate standards and specifications for vegetative practices.

    - For design velocities of less than 3.0 fps, seeding and mulching may be used for the establishment of the vegetation.
    - For design velocities of more than 3.0 fps, the waterway shall be stabilized with seeding protected by jute, excelsior matting, or with seeding and mulching including temporary diversion of the water until the vegetation is established.

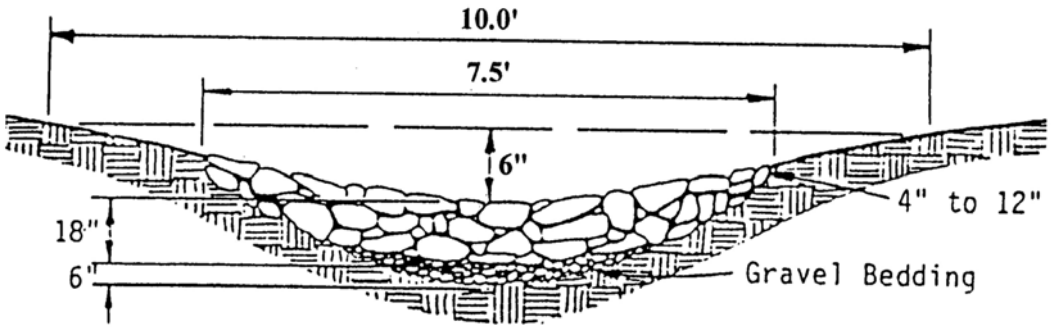

Figure 2.3. Waterway (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Instructions for Figure 2.4

Wood excelsior matting is one example of special ditch control. Materials and methods for installation shall conform to current standard specifications and to specifications as directed by the engineer. Other mat-type materials may be considered by the engineer for this purpose.

The wood excelsior mat shall be subject to approval by the engineer at the job site. Approval of the final project constitutes approval of the material.

At locations where silt conditions require shaping of a ditch to provide proper types of area for installing the wood excelsior mat for special ditch control, the necessary excavation shall be done by the contractor.

All excavated material should be used to fill low areas, gullies, backslope scours, and otherwise facilitate the free flow of surface water into the channel as directed by the engineer. Alignment should be smooth and abrupt changes should be avoided.

At locations where erosion has created gullies in ditches or backslopes, the gullies shall be filled and compacted in lifts not more than eight inches.

The wood excelsior mat shall comply with the following minimum requirements:

- The mat shall have interlocking wood fibers with plastic netting applied to both sides to hold the excelsior in place.

- The mat shall be nontoxic to the growth of plants and germination of seeds.
- The mat shall be furnished in rolls as follows:
  - Width of strips: minimum 48 in.
  - Length of rolls: minimum 180 ft
  - Minimum weight per sq yd: 0.88 lbs

The netting applied to both sides of the mat shall have a mesh size approximately 5/8 in. by 3/4 in. Netting shall be polypropylene and black in color. The material shall be furnished in plastic bags or otherwise protected to prevent damage from handling and weather conditions.

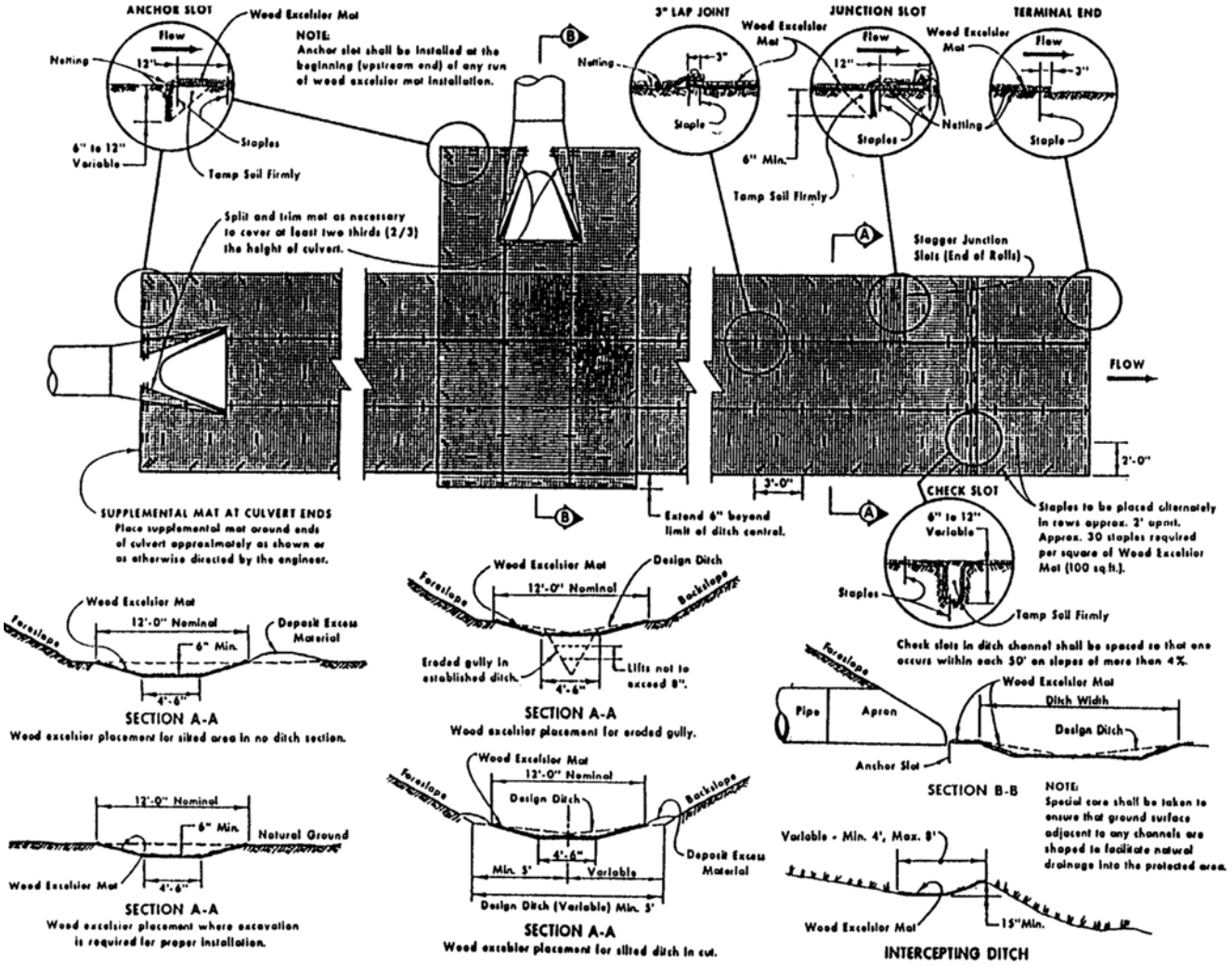

Figure 2.4. Special ditch control (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

2.2 DUST CONTROL

Figure 2.5. Truck-mounted dust-control applicator (Source: http://soiltac.com/Photo_Gallery.html)

Overview

Description: A chemical product applied to the exposed soil surface to prevent the movement of dust that may be harmful to human health.

Problem identification: Fugitive dust becomes airborne by wind or by vehicle movement due to construction site areas that are devoid of vegetation and moisture.

Design purpose: To prevent surface air movement of dust from exposed soil surfaces.

Associated practices: Becomes a problem when surface vegetation is destroyed and construction begins, with borrows and construction roads.

Installation: A number of materials can be used, such synthetic resin, lignosulfanate, or soybean oil. See Table 2.1. In some cases, calcium chloride is used on roads. Other options are temporary seeding, roughening the soil surface, or erecting snow fences or other barriers.

Table 2.1. Dust control methods—dilution and rates of application

Adhesive	Water dilution	Nozzle	Rate, gal/ac
Resin emulsion	4:1	Fine	300
Lignosulfanate	1:1	Coarse	1,815
Soybean soil (soapstock)	Undiluted	Coarse	1,210-2,420

Maintenance/inspection: Exposed soil must be protected before dust becomes a problem.

Design life: Varies with season and treatment, up to several weeks.

Estimated cost: $.03 to $.07 per sq ft

Figure 2.6. Manual dust-control applicator (Source: http://soiltac.com/Photo_Gallery.html)

2.3 MULCHING

Figure 2.7. Mulching (Source: www.usda.govstream_restorationnewgra.html)

Overview

Description: Application of plant residue or other suitable material to the soil surface.

Problem identification: The existing soil surface is devoid of vegetation and moisture, causing soil to become airborne and be transported off the construction site due to wind or vehicle movement.

Design purpose: To reduce runoff, conserve moisture, and reduce erosion and sedimentation.

Associated practices: Used on bare soil with either temporary or permanent seeding; may be used without seeding to protect critical areas; used after grading, in drainage areas, etc.

Installation: Many materials can be used for mulching. The most readily available include grain straw, hay, wood chips or bark, wood cellulose fiber, wood excelsior, and gravel or crushed rock. For mulch to blend with the soil, the soil should be loosened. Since seedbed preparation requires that the soil be tilled to a depth of three inches, this preparation provides ideal soil surface treatment for the application of mulching. Proper application rates are important. Application rates are as follows:

1. Dry straw: Apply 1.5–2 tons per acre, 70 lbs per 1,000 sq ft. Straw mulching can be applied either by machine or by hand. The straw needs to be anchored to the soil. One method of anchoring is pressing the straw into the soil with a mulching tiller (a machine designed for this purpose), or applying a cutback asphalt tack at 1,200 per acre. Mulching applied at the correct rate will allow approximately 50% of the soil to be visible.
2. Hay: Apply 2 tons per acre, 90 lbs per 1000 sq ft. The remainder of application is the same as straw.
3. Wood chips or bark: Apply 10 to 12 tons per acre. This can be applied by machine or by hand. The material decomposes slowly, and it is good, long-lasting mulch.

4. Wood cellulose fiber: Requires 1,000 to 1,200 lbs per acre. The fiber must be applied with a hydroseeder. Mulching must be applied after the seed and fertilizer have been incorporated into the soil.
5. Wood excelsior: Apply at rate of 2 tons per acre. This material lasts longer than straw and is free of weeds. It can be applied by machine or by hand. Like straw, it should be incorporated into the soil.
6. Crushed rock or gravel: Apply at rate of 40 cu yds per acre or 1.5 cu yds per 1000 sq ft. The recommended size is three-fourths to one in. These specifications will result in rock mulching being placed one rock thick, and 50% of the soil should be visible. This is excellent mulching for short slopes or areas that will be subject to light traffic. It may also be placed over black plastic to control weeds.

Maintenance/inspection: Inspect after heavy storm runoff. Look for small areas of erosion or where the mulch has washed away. All areas of failure should be repaired at once.

Design life: Varies, three months to one year.

Estimated costs: Unit cost is dependent on local material cots.

2.4 SEEDING AND FERTILIZING

Figure 2.8. Seeding and fertilizing (Source: Iowa DOT)

Figure 2.9. Grain drill seeding (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Overview

Description: Establishment of grasses and or legumes on disturbed areas. Note: A ground cover of grass is the most effective method for controlling erosion.

Problem identification: To reduce erosion and sedimentation. Bare areas of soil exposed to the elements contribute sedimentation and dust.

Design purpose: To reduce erosion and damage to downstream resources and improve the soil for permanent plantings.

Associated practices: Applies to all disturbed areas devoid of vegetation, unless a specific reason causes vegetation to be inappropriate, such as in protecting slopes, waterways, etc.

Installation: Effective reduction in erosion can be achieved by either temporary or permanent seeding. Temporary seeding is short-lived and will lose its effectiveness in six to nine months. The procedure for temporary seeding will be addressed first.

When it becomes evident that a disturbed area in a construction site will not be disturbed for 21 days, it shall be seeded before day 14. However, if excavated material is present, the disturbed area should be seeded or surrounded by a silt fence.

Temporary Seeding

1. Prepare seedbed to a depth of three in. Before final preparation, apply 400 lbs of 13-13-13 fertilizer per acre (10 lbs per 1,000 sq ft) and incorporate it into the seedbed.
2. Roll the area to be seeded with an approved cultipacker.
3. Apply seed with an approved seeder.
4. Roll the seeded area. If the seeded area is relatively flat, the seeding operation is completed.
5. Mulching will be beneficial if the seeded area is steeper than a 3:1 slope or faces south or southwest. The rate of application is 1.5 tons per acre (70 lbs per 1,000 sq ft).
6. Till the mulched area with a mulching tiller.

If a hydroseeder is used to apply hydromulching, it must be applied at the rate of 2,000 lbs per acre and as the final operation. It is not permitted to apply seed and fertilizer with the mulching.

There are several types of temporary seeding:

- Perennial ryegrass, 40 lbs per acre (1 lb per 1,000 sq ft)
- Oats, 48 lbs per acre (1.2 lbs per 1,000 sq ft). Plant March 1 to May 20.
- Sudangrass, 35 lbs per acre (0.8 lb per 1,000 sq ft). Plant May 21 to August 14.
- Winter rye, 64 lbs per acre (1.6 lbs per 100 sq ft). Plant August 15 to September 30.

Permanent Seeding

1. Prepare seedbed to a depth of 3 in. Before final preparation, apply 700 lbs of 13-13-13 fertilizer per acre (12 lbs per 1,000 sq ft).
2. Roll seedbed with an approved cultipacker.
3. Apply seed with an approved seeder.
4. Roll seedbed.
5. Apply mulching uniformly at rate of 1.5 tons per acre (70 lbs per l,000 sq ft).
6. Till all areas mulched on the contour with a mulching tiller.

There are several types of permanent seeding:

- Lawn grass mixture, 80 lbs per acre (2 lbs per 1,000 sq ft): bluegrass 60%, perennial ryegrass 20%, creeping red fescue 15%, and white dutch clover > 5%.
- Tall grass mixture, 40 lbs per acre, (1 lb per 1,000 sq ft): Ky 31 fescue 50%, switchgrass 10%, orchardgrass 20%, bromegrass 15%, and alsike clover 5%.

Maintenance/inspection: Inspect once a month and note the stand of grass; look for areas where runoff water may have caused rills to form or where lack of moisture may have caused seedlings to die. All areas showing stress should be corrected. It may be necessary to reprepare the seedbed, reseed, and remulch.

Design life: Temporary seeding varies by season; permanent seeding is permanent.

Estimated costs: Temporary seeding: $233 per acre.
Mulching: $350 per acre.
Permanent seed, fertilizer, and mulching: $945.00 per acre.

2.5 SILT FENCE

Figure 2.10. Silt fence (Source: Iowa DOT)

Overview

Description: A temporary barrier of geotextile fabric (filter fabric) used to intercept runoff from small drainage areas of disturbed soil to allow the sediment to settle out of the runoff water. Silt fences are one of the most convenient control measures to use on all projects that involve soil disturbance.

Problem identification: Exposed soil areas are subject to water erosion and sediment movement during and after storm water events. Materials and methods are required to eliminate soil loss or movement of soil across construction sites from such events.

Design purpose: To trap sediment from sheet flows before it leaves the construction site. Silt fences are effective in trapping sediment from all activities that involve soil disturbance. The fences can be used on adjacent properties, adjacent bodies of water, large sloping areas, near streams and waterways, and near surface drainageways.

Associated practices: Used in conjunction with silt traps and basins, temporary seeding, and ditch checks to limit the amount of sediment that approaches the silt fence.

Installation: Tables 2.2 and 2.3 show the suggested spacing on slopes and in ditches that contribute runoff to a silt fence area.

Table 2.2. Silt fence spacing on slopes

Slope	Placement interval, ft
3:1 (33%)	40
4:1 (25%)	50
5:1 (20%)	60
10:1 (10%)	100
≤ 50:1 (2%)	150

Table 2.3. Silt fence spacing in ditches

Ditch grade, %	Approximate spacing, ft
1-2	150
2-4	75
4-6	40
>6	25

The maximum drainage area flow to a silt fence should not exceed 1/4 acre per 100 ft of fence. Most erosion will occur in the form of sheet erosion, with no concentrated water flow to the fence.

Silt fences should be placed as close as possible to the undisturbed soil.

All filter fabric shall comply with the specifications set forth by the Iowa Department of Transportation.

Steel posts must be used.

Note other control measures, filter strips, and inlet protection.

Maintenance/inspection: Inspect once a week and after each rainstorm; look for undercutting and failures in fabric. Clean and dispose of sediment as necessary; repair water damage and fabric failures at once.

Design Life: Until sediment accumulates to one-half the height of the fence.

Estimated cost: Silt fence: $2.80 per linear ft.

Instructions for Figures 2.11 and 2.12

The following details describe various methods of silt fence construction that may be required for the control of siltation on a project. The contractor shall be responsible for accomplishing the required silt fence construction work on the project in such a manner as to effectively minimize and control the water pollution that might be caused by soil erosion from the project. These features are intended to be maintained in appropriate functional condition from the initial construction stages to completion of project.

In addition to the details shown in Figure 2.11 and Figure 2.12, other provisions for controlling erosion may be incorporated into the project work.

Steel line posts for the field fence (T-section), exclusive of an anchor plate, shall weigh not less than 1.3 lbs per ft.

All compaction of backfill shall be performed with a mechanical tamper or pneumatic tamper. All compacting equipment shall be operated according to the manufacturer's recommendations.

Installation Notes (numbers match those on Figures 2.11 and 2.12)

1. Secure top of geotextile fabric to steel post (see detail of attachment to post).
2. Fold engineering fabric across the bottom of the trench.
3. Make vertical cut in top fold area of fabric. Pull out and twist cord.
4. Loop cord around post to form a loop. Pull wire through fold area of fabric and secure around post.
5. Steel post to be embedded 28 in. below trench bottom.
6. Minimum trench size should be 12 in. deep by 4 in. wide; compact the backfill.

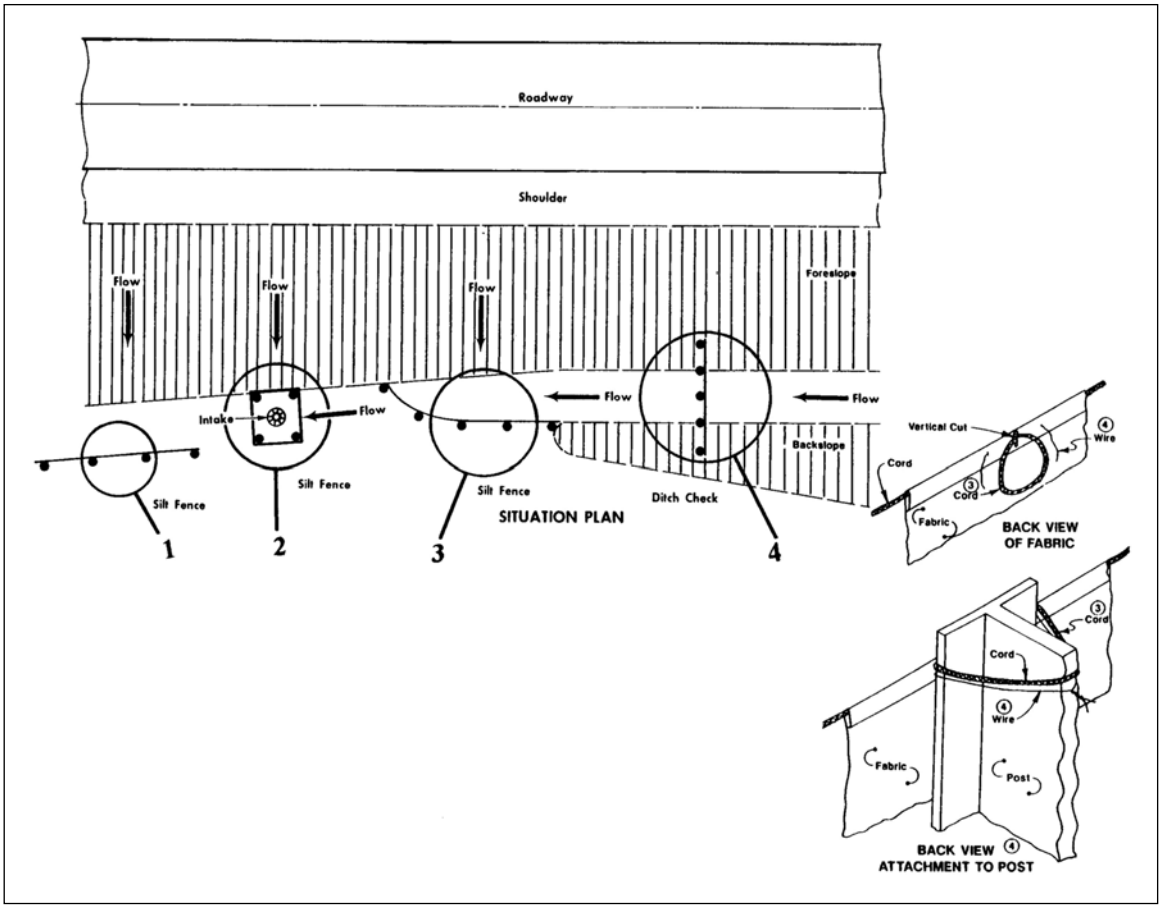

Figure 2.11. Silt fence situation plan (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

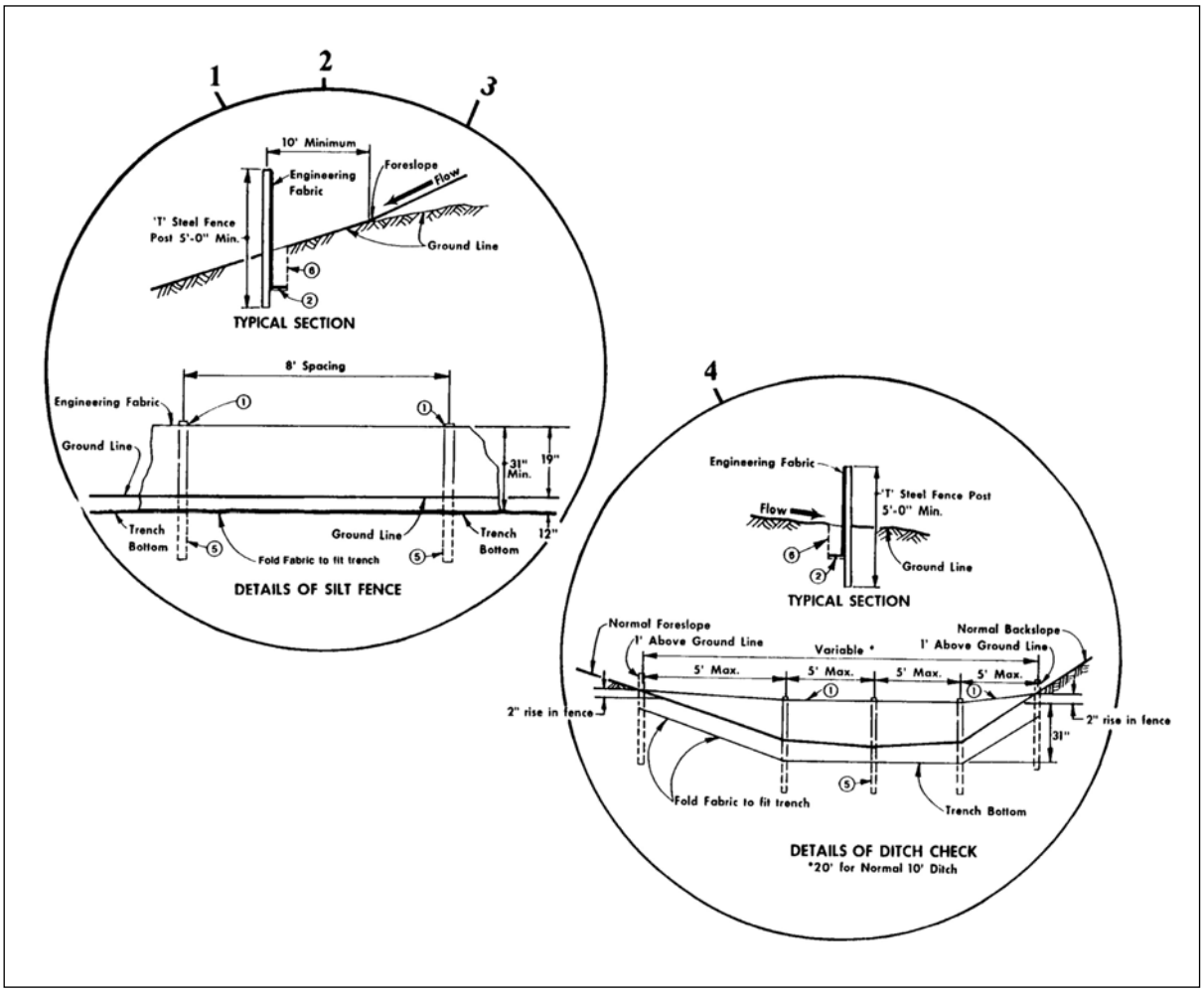

Figure 2.12. Enlargements of number elements in Figure 11 (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Figure 2.13. Improper silt fence installation (Source: Minnesota DOT)

Figure 2.14. Proper silt fence installations (Source: Iowa DOT)

2.6 SODDING

Figure 2.15. Sod truck (Source: Urban Resources and Borderland Alliance Network)

Overview

Description: To cover bare soil with cut sod, usually bluegrass, to provide rapid stabilization of the soil.

Problem identification: Waterways, rock chutes, flumes, and some slopes require rapid vegetation establishment to control soil loss due to wind or water erosion.

Design purpose: To control erosion or dust and enhance the area, or to protect rock chutes, flumes, and waterways from erosion with sod.

Associated practices: Sod is placed in areas where vegetative cover is needed rapidly.

Installation: Sod is usually bluegrass or a mixture of bluegrass and creeping red fescue. Sod may be 12 or more in. wide, 3 or more ft long, and approximately 3/4 of an in. thick.

Sod should be installed within 36 hours of being cut.

The sodbed surface should be smooth and firm and free of all debris or other objects that would interfere with sodding or with the final finish. If the area has been subject to construction traffic compaction, the underlying soil bed should be loosened to a depth of two to three inches to aid in root growth.

Sod placed on slopes 3:1 or steeper should be staked.

Apply fertilizer at the rate of 10 lbs of 13-13-13 fertilizer per 1,000 sq ft before the sod is placed. After the sod is placed, it should be rolled to ensure firm contact with the soil. Immediately after rolling, the sod shall be thoroughly watered so the ground is wet at least 4 in. beneath the sod.

For the first two weeks, the sod should be watered three times a week or every two or three days. Watering must done so wet soil is present four in. below the sod. For the next two weeks, the sod should be watered twice a week (for example, every three days), and again the ground should be soaked to four in. below the sod.

Maintenance/inspection: Inspect on a weekly basis to ensure that there are no dry areas or that the sod has not been damaged by heavy precipitation. If hot, dry weather prevails after 28 days of watering, additional water may be necessary. Any damaged areas of the sod should be replaced. Do not mow until the roots are well established and the sod is firm. No more than one-third of the grass leaf should be removed by the first mowing.

The second application of fertilizer should be applied one month after the sod was installed. Use 8 lbs of 13-13-13 fertilizer per 1,000 sq ft.

Design life: Permanent.

Estimated cost: Sod and 28-day water period: $49.00 per 100 sq ft.

Instructions for Figures 2.16 and 2.17

Grading and shaping may include the removal and disposal of excess earth in order to obtain satisfactory drainage and appearance for the finished work.

Sod channels should be constructed at the low point through ditches or borrow areas. All excavated material should be wasted to fill low areas and otherwise facilitate the free flow of surface water into the channel. Alignment should be smooth. Abrupt changes should be avoided.

At locations where silt conditions require shaping of a ditch to provide a proper area for installing sod for special ditch control, necessary excavation shall be done by the contractor with the excavated material disposed of in adjacent areas at the direction of the engineer.

At locations where erosion has created gullies in ditches or backslopes, the gullies shall be filled and compacted in lifts not more than eight in.

Special care shall be taken to ensure that the ground surface adjacent to any sod channels is shaped to facilitate natural drainage into the sodded area.

Where directed, the contractor will be required to stake the sod in place to minimize erosion damage, with a minimum of 33 stakes per square. Wooden stakes shall be used in sod flumes. Longer stakes may be required for certain soil conditions to properly hold the sod in place.

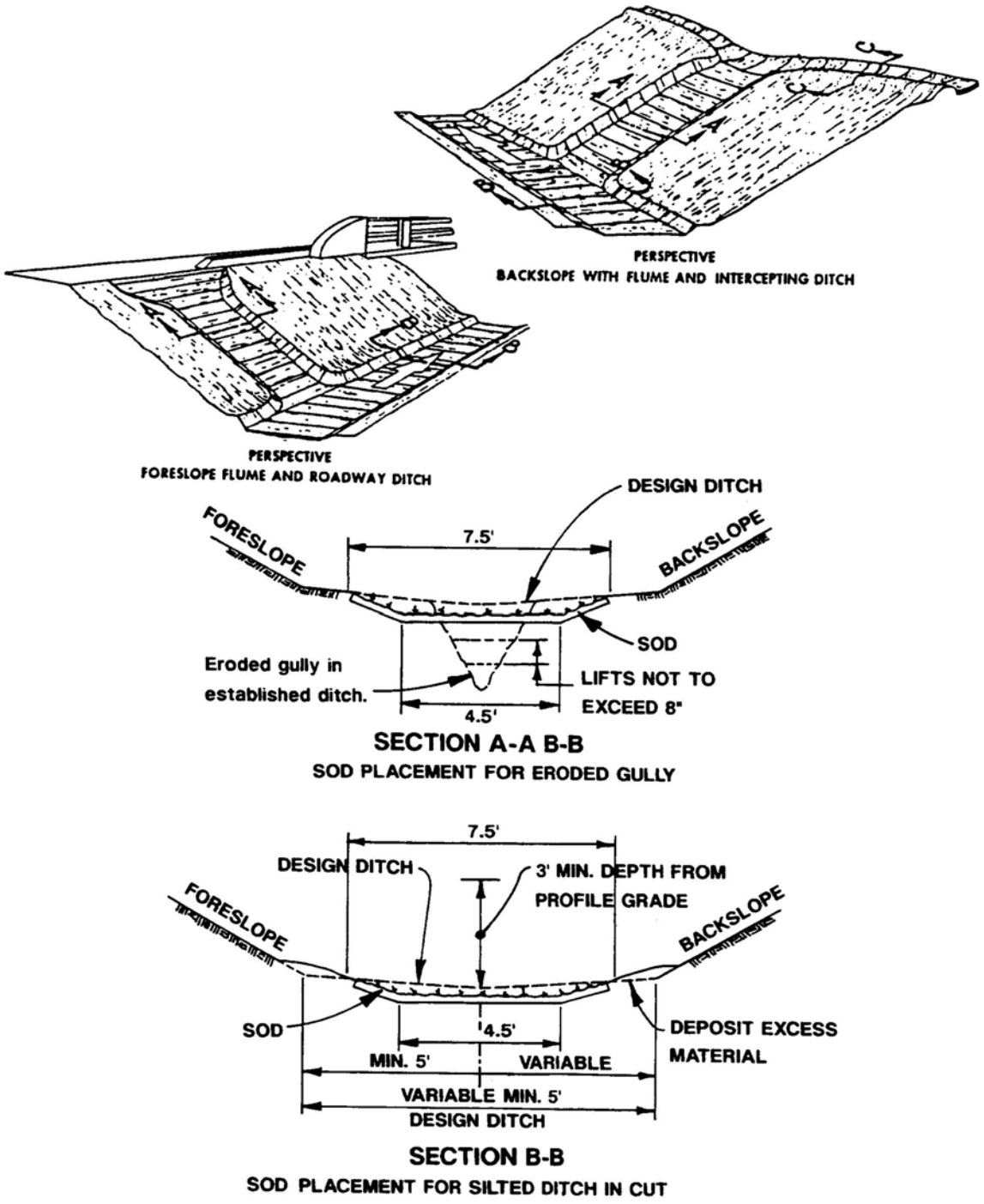

Figure 2.16. Sod placement in eroded gully and silted ditch (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

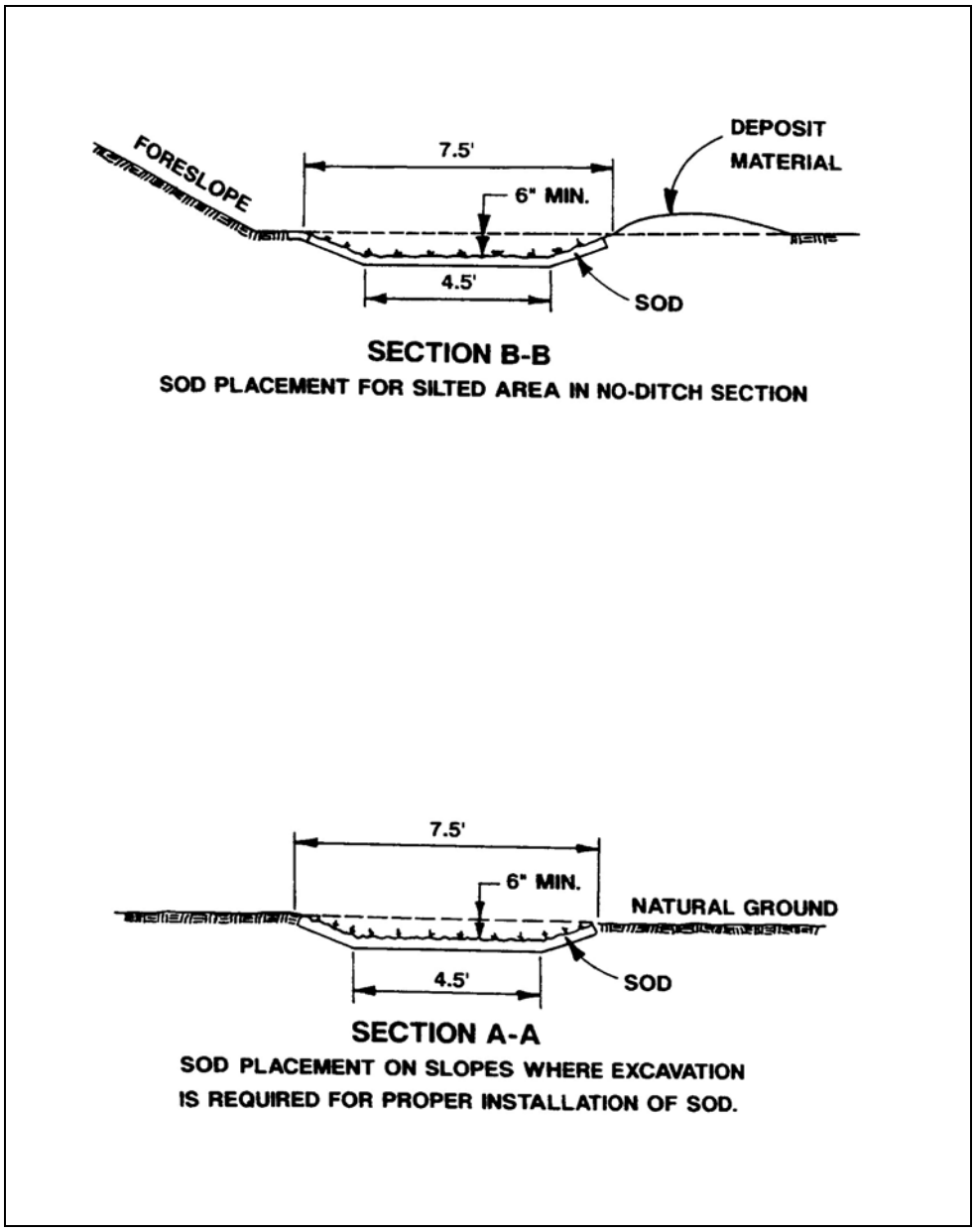

Figure 2.17. Sod placement in no-ditch and slope situations (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

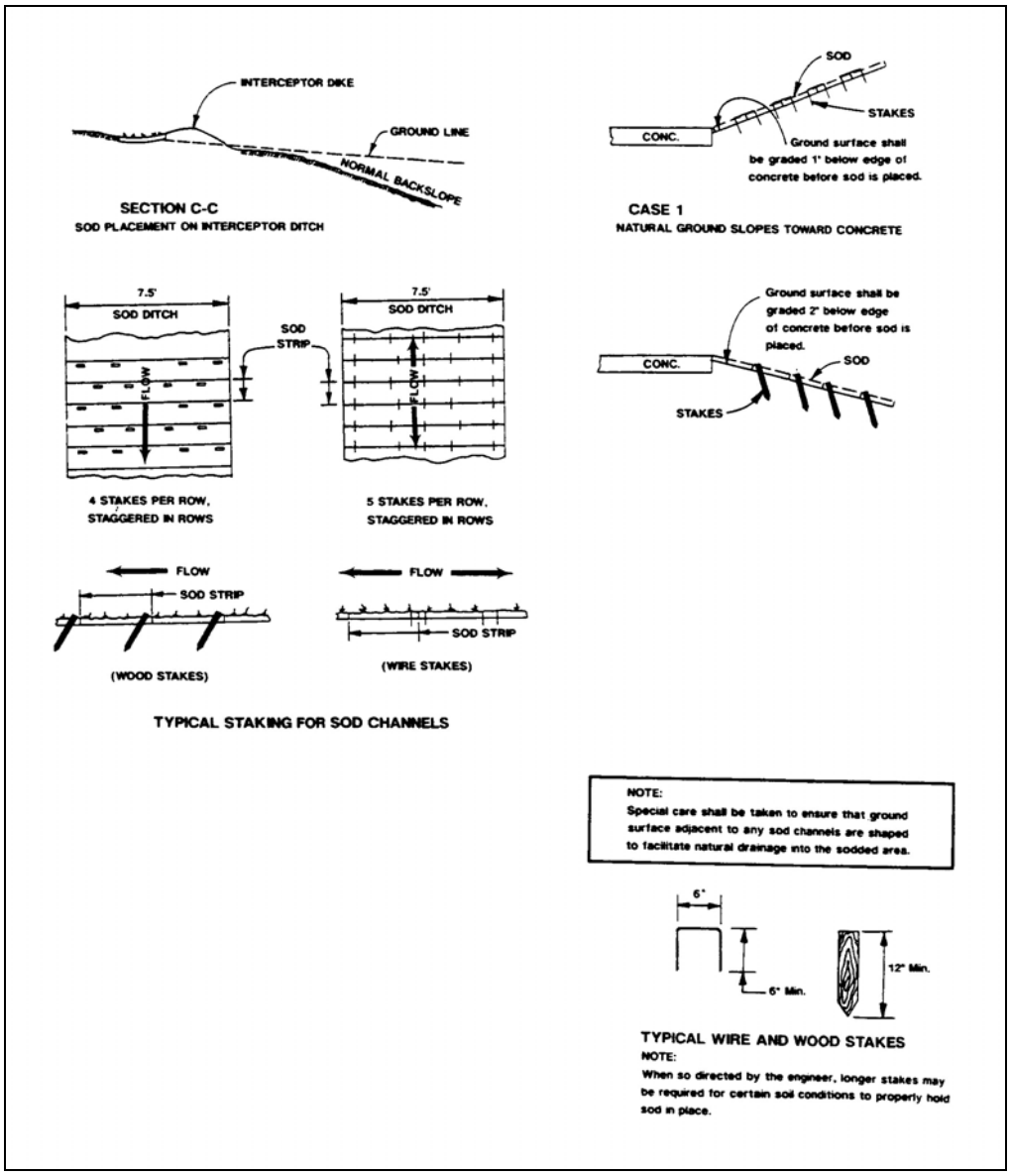

Figure 2.18. Sod staking (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

2.7 SURFACE ROUGHENING

Figure 2.19. Surface roughening by disking (Source: Iowa DOT)

Overview

Description: A rough finish on the soil surface with clods three in. across or larger, made by operating a rome disc or other tillage equipment on the contour.

Problem identification: During winter months when the soils do not support vegetation, other erosion control measures must be considered.

Design purpose: Surface roughening reduces runoff velocity, reduces dust, increases infiltration, reduces erosion, traps sediment, and aids in the establishment of vegetative cover with seed. When a finished, graded area cannot be seeded within 14 days, or if finish grading is completed outside the seeding dates, the area should receive a surface roughening treatment. This method should only be used during the late fall or winter months when seeding cannot be done.

Associated practices: Used with slope protection, seedbed preparation, and grading.

Installation: All exposed soil areas should be roughened to a depth of four to six in. when the above conditions are present. All equipment movement must be on the contour. It is important that the tillage depth be achieved with one pass of the equipment: it is important not to overwork the soil. Rough surfaces with uneven soil may appear unattractive or unfinished; however, the rough finish encourages water infiltration, speeds the establishment of vegetation, and decreases runoff velocity. This method should be used in clay soils. Areas on which surface roughening has been used should be seeded as soon as weather conditions permit in the next seeding period.

Maintenance/inspection: Inspect for erosion damage after severe rainstorms. Look for rivulets and small gullies. Areas of damage may be retilled, or the soil may be reworked and mulched.

Design life: Two months in nonfreezing weather; six months in freezing weather.

Estimated cost: Tillage: $49.00 per acre.

2.8 VEGETATIVE FILTER STRIP

Figure 2.20. Roadway filter strip (Source: Iowa DOT)

Overview

Description: Grass may be used effectively to control dust, protect soil from erosion, and trap sediment.

Problem identification: Water-borne erosion and sediment accumulation can occur in and near natural drainageways and at intermediate locations in sloping soil.

Design purpose: To protect soil, improve the visual aspects of the site, and trap sediment.

Associated practices: May be used to identify property boundaries and enhance the banks of waterways and channels. Vegetative filter strips also help stabilize the soil and trap silt. Filter strips can be a part of seeding, fertilizing, and mulching control measures, slope grading, etc.

Installation: Existing turf should be undisturbed during construction and overseeded with native grasses and forbs to enhance vegetation growth during construction. Refer to the control measure procedure for seeding and fertilizing in Section 2.4. Vegetative filter strips can be installed where a long, flat slope allows sheet flows. A 30 ft wide strip of grass will filter a high percentage of sediment from runoff water. Temporary seeding mixtures should be applied during the construction period, followed by permanent seed mixtures or native grasses.

Maintenance/inspection: Inspect on a monthly basis and look for erosion and areas of failure. Repair erosion areas and reseed if necessary.

Design life: Permanent.

Estimated cost: Fertilizing, seeding, and mulching: $945.00 per acre.

Figure 2.21. Vegetative filter strip (Source: photogallery.nrcs.usda.gov)

Figure 2.22. Urban filter strip (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

2.9 COMPOST BLANKETS

Figure 2.23. Blown compost blanket (Source: Iowa Natural Resources Conservation Service 2004)

Overview

Description: A one- to four-inch surface application of compost or mulch or a blend of both to protect areas with erosive potential.

Problem identification: Areas disturbed during times when vegetation has difficulty establishing itself need to be protected from erosion and sediment loss.

Design purpose: Reduction in the erosion of flat to moderate slopes and in the loss of sediment prior to vegetation establishment.

Installation: The materials can be placed at any time during the year. The thickness should be between two to four in., in accordance with the slope and Table 2.4. Generally, the steeper the slope, the thicker the blanket, and coarser compost should be placed on steeper slopes. Place the blanket on the disturbed surface, but do not till into the surface. It is suggested that compost socks be placed at the top of the slope to reduce the velocity of water over the crest of the slope onto the compost blanket. On long slopes or severe slopes (2:1 or greater), slope protection consisting of silt fences or compost filter tubes should be added at spacings not exceeding 25 ft.

Table 2.4. Compost blanket thickness on slopes

Slope	Compost thickness
2:1	4”
3:1	3”
4:1	2”

Maintenance/inspection: Blanket areas should be inspected immediately after rainfall, and areas damaged by splash, sheet, or rill erosion should be repaired prior to additional rainfall.

Design life: One year.

Estimated cost: Cost varies with the availability of the product.

2.10 COMPOST FILTER TUBES

Figure 2.24. Compost filter tube (Source: SUDAS Design Manual)

Overview

Description: A mesh sock filled with a blend of compost materials that is used to slow flow velocity, capture and degrade chemical pollutants, and trap sediment.

Problem identification: Sloping and disturbed areas require multiple devices to divide the length of the slope into short sections and reduce the flow quantity and velocity of the water. Inlets require methods for collecting sediment before sediment reaches the inlet openings.

Design purpose: Multiple purposes, including inlet protection, slope erosion control, perimeter control, and flow diversion.

Installation: The particle size must be selected in light of the soil gradations that are to be retained by the device. These devices should be installed along the contour, as with silt fences. Do not place on slopes in excess of a 10% grade. Spacing should be determined to allow the bottom of the next higher tube to be seen from the one being installed below. Place at least five feet from the toe of a slope to provide for the formation of a sediment basin. The tubes should be staked and additional compost placed in front of each tube to enhance the ability to collect sediment.

Tubes placed on slopes should be spaced in accordance with Table 2.5.

Table 2.5. Maximum compost tube spacing

Slope	Tube diameter (ft)	
	8”	12” or greater
0% - 2%	75’	125’
2% - 5%	50’	75’
5% - 10%	30’	50’

When used for inlet protection, the tube should be placed in front of the inlet opening and staked behind the curb to hold the tube in place. The tube should be use in conjunction with a mat over the surface openings to prevent sediment from entering the intake.

Maintenance/inspection: Tubes should be inspected immediately after rainfall. Sediment should be removed when the height of the sediment reaches one-third of the tube height. The tube must be replaced or expanded if breached or water finds ways around the tube.

Design life: Six months.

Estimated cost: Varies with the availability of the product.

2.11 ROLLED EROSION CONTROL PRODUCTS

Figure 2.25. Backslope protection (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Figure 2.26. Foreslope protection in growth stage (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Overview

Description: Rolled erosion control products (RECP) consist of prefabricated blankets or netting formed from natural and synthetic materials.

Problem identification: Steep slopes in urban areas require measures to assist in the establishment of vegetation and reduce the opportunity for erosion of the surface.

Design purpose: The RECP materials provide protection to the seed and the underlying soils to reduce the chance of erosion and sediment movement on slopes. RECPs enhance moisture retention to allow for the growth of the seeding applied to the surface. The materials degrade over time and retard unwanted plant growth, reducing maintenance.

Installation: The materials should be installed in conjunction with the manufacturer's recommendations. RECPs may be used in channels or on slopes. General recommendations for installation are found in Table 2.6.

Maintenance/inspection: Damaged areas should be repaired immediately until the vegetation is established and growing through the material.

Design life: Varies with product selection (three to six months).

Estimated cost: Varies with the product selected.

Figure 2.27. Wood excelsior mat (Source: North American Green)

Table 2.6. Typical rolled erosion control product properties and uses* (Source: Lancaster & Austin 2004)

Type	Product description	Material composition	Slope applications Max. grade	Channel applications Permissible shear stress*
Ultra short-term: Typical 3-month functional longevity				
1.A	Mulch control nets	Photodegradable synthetic mesh or woven biodegradable natural fiber netting	5:1 (H:V)	0.25 lbs/ft^2
1.B	Netless rolled erosion control blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP	4:1 (H:V)	0.5 lbs/ft^2
1.C	Single-net erosion control blankets & open weave textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	3:1 (H:V)	1.5 lbs/ft^2
1.D	Double-net erosion control blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic, or natural fiber nettings.	2:1 (H:V)	1.75 lbs/ft^2
Short-term: Typical 12-month functional longevity				
2.A	Mulch control nets	Photodegradable synthetic mesh or woven biodegradable natural fiber netting	5:1 (H:V)	0.25 lbs/ft^2
2.B	Netless rolled erosion control blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP	4:1 (H:V)	0.5 lbs/ft^2
2.C	Single-net erosion control blankets & open weave textiles	Erosion control blanket composed of processed degradable natural or polymer fibers mechanically bound together by a single degradable synthetic or natural fiber netting to form a continuous matrix or an open weave textile composed of processed degradable natural or polymer yarns or twines woven into a continuous matrix.	3:1 (H:V)	1.5 lbs/ft^2
2.D	Double-net erosion control blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two degradable synthetic or natural fiber nettings.	2:1 (H:V)	1.75 lbs/ft^2
Extended-term: Typical 24-month functional longevity				
3.A	Mulch Control Nets	Slow degrading synthetic mesh/woven natural fiber netting	5:1 (H:V)	0.25 lbs/ft^2
3.B	Erosion control blankets & open weave textiles	Erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	1.5:1 (H:V)	2.0 lbs/ft^2
Long-term: Typical 36-month functional longevity				
4	Erosion control blankets & open weave textiles	Erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	1:1 (H:V)	2.25 lbs/ft^2

*Refer to SUDAS Manual, Chapter 7, Section 7E-9 (Turf Reinforcement Mats) for additional information on determining shear stress in a channel. Minimum shear stress RECP (unvegetated) can sustain without physical damage or excess erosion (0.5 in. soil loss during 30-minute flow event).

Instructions for Wood Excelsior Mat as Slope Protection

The work of providing a suitable earth surface for the placement of slope protection shall be considered crucial to preparing the seedbed. Special care shall be taken to ensure that ground surfaces adjacent to any channels are shaped to facilitate natural drainage into the protected area. Seedbed preparation, seeding, and fertilizing shall be performed in accordance with standard specifications. Prior to the placement of wood excelsior matting, the ground shall be uniformly even with the surface of any adjacent concrete.

Excelsior matting for backslope protection is installed with strips placed perpendicular to the roadway. The location for slope protection shall be performed as shown on the detail plan. The excelsior mat for foreslope protection is installed with strips placed parallel to the roadway.

The wood excelsior mat shall comply with the following minimum requirements:

- The mat shall have interlocking wood fibers with a plastic netting applied to both sides to hold the excelsior in place. The mat shall be non-toxic to the growth of plants and the germination of seeds.
- The mat shall be furnished in rolls as follows:
    - Width of strips, min. 48 in., plus or minus 1 in.
    - Length of rolls, min. 180 ft
    - Minimum weight per sq yd, 0.88 lbs

The netting applied to both sides of the mat shall have a mesh size approximately 5/8 in. to 3/4 in. Netting shall be polypropylene and black in color. The material shall be furnished in plastic bags or otherwise protected to prevent damage from weather conditions and handling.

Directions

1. Space two rows of staples at 18 in. centers, the bottom row at 36 in. centers, and all others staples at 24 in. centers.
2. Where erosive gullies have developed in the backslope, the gullies shall be filled with soil and compacted prior to placement of the mat.
3. There shall be a four feet minimum, an eight feet maximum, or as specified. Place staples the same as is required for special ditch control.
4. Where excelsior mat is to be placed as special ditch control, the slope protection shall be installed to facilitate placement of the ditch control.
5. Foreslope protection shall be four ft, zero in., unless otherwise specified.
6. If an erosive rill has developed adjacent to the shoulder material, it shall be filled with suitable soil and compacted prior to placement of mat.

2.12 WATTLES

Figure 2.28. Coconut fiber roll (Source: Natural Resources Conservation Service)

Overview

Description: A sediment velocity control device made of tubes of straw, rice straw, or coconut husk encased in an ultraviolet-degradable plastic netting or 100% burlap material. Wattles help stabilize slopes by breaking up the length of the slope or by slowing and spreading the overland flow of water.

Problem identification: Sloping disturbed areas requires multiple devices to divide the length of the slope into short sections and reduce flow quantity and velocity.

Design purpose: Provide devices that are biodegradable over time, but that reduce water flow velocities on slopes and allow for sedimentation to remain on the slopes while vegetation is being established.

Installation: Wattle locations should be established in the same manner as compost tubes, but are installed in shallow trenches (two to four in. deep). Excavated materials are placed on the upstream side of the wattle to initiate sediment collection. The wattles must be staked with wooden stakes and left in place during the establishment of vegetation on the slope. The size of the wattle should be determined using the Table 2.7.

Table 2.7. Recommended wattle spacing by slope

Slope	Spacing intervals (ft)	
	9″ diameter	12″ diameter
<4:1	20’	40’
2:1 to 4:1	15’	30’
2:1 or greater	10’	20’

Wattles can be used for inlet protection, but are better suited to slope work.

Maintenance/inspection: To enhance the retention capability of the wattle, sediment should be removed on a routine basis when the level of sedimentation reaches one-half the height of the exposed wattle. Damaged areas should be repaired immediately until the vegetation is established and growing through the material.

Design life: Varies with product selection (three to six months).

Estimated cost: Varies with the product selected.

2.13 FLOCCULENTS

Overview

Description: Flocculents are natural materials or chemicals that cause colloidal particles (clay) to coagulate and remove themselves from the water flow in surface runoff.

Problem identification: It is difficult to remove large amounts of fine particles from water runoff in a reasonable amount of time.

Design purpose: Helps reduce the time of detention in detention ponds and increases the ponds' capacity to handle larger storm runoff quantities in the specified design time.

Installation: The flocculent must be added at the time the detention basin is experiencing an inflow of runoff, at a manufacturer-specified rate, and must be mixed constantly with the stormwater. After mixing with the stormwater, the detention pond water must be allowed calm and let the flocculent work. Lastly, the outflow from the basin must be monitored to ensure that the flocculent is removed by settling.

Maintenance/inspection: Sediment should be removed on a routine basis to ensure enough volume to receive the sediment. Timing will be based on the amount of ample storage volume to accommodate anticipated runoff. Retention time and sediment storage volume are critical.

Design life: Only effective for the volume of water in the detention pond at one time.

Estimated cost: Varies with the product selected.

2.14 TURF REINFORCEMENT MATS

Overview

Description: Turf reinforcement mats (TRMs) are three-dimensional matting products, constructed from non-degradable synthetic materials or a composite of degradable and non-degradable materials. The matting reinforces the root structure of the vegetation to create a system that can withstand high shear stresses. TRMs are used mainly in channels, ditches, and other high-flow applications in which vegetation alone cannot withstand the erosive forces of the flow.

Problem identification: Some existing channels, ditches, and other areas subject to high-velocity flows, such as pipe outlets, require special structural devices to protect the ditch sides and bottom from erosion. Some vegetated channels are required to withstand flow velocities between 10 and 20 fps.

Design purpose: Several purposes. Immediately after installation, the TRM provides significant stabilization to the disturbed surface on which it is placed. The mat promotes the growth of vegetation by maintaining consistent moisture and temperature levels. As the vegetation grows down through the mat, the roots become interlocked with the matting, providing a system with a high resistance to erosion.

Advantages:

- Withstands high shear stress from flowing water
- Provides permanent, long-term reinforcement of vegetation
- Vegetation creates a more aesthetically pleasing appearance than “hard armor” techniques
- Stabilizes ground where vegetation is difficult to establish
- Usually a less expensive alternative to “hard armor” techniques

Limitations:

- With numerous products available, appropriate product selection can be difficult
- Can withstand a limited amount of flow before “hard armoring” is required

Associated practices: Used with RECPs, riprap, or other hard armor techniques.

Installation: Turf reinforcement mats should be installed in locations where vegetation alone cannot withstand the anticipated flow velocities, where hard armor is not necessary, or where hard armor will be visually unappealing.

Most TRM products are designed and rated for resistance to shear stress. Shear stress in channels lined with TRMs is calculated in the same manner as for grass channels. If the channel is to be vegetated, a variable Manning coefficient will need to be calculated. If the channel is being analyzed for performance with the TRM alone, a constant Manning coefficient provided by the manufacturer may be used.

After calculating the shear stress in the channel, an appropriate TRM that will withstand the anticipated stress can be selected. Many TRM manufacturers provide software to aid in the

calculation of shear stress and the selection of an appropriate TRM. This software may be available through the manufacturer's website or a local product representative.

TRMs should be installed in accordance with the manufacturer's recommendations. The general procedure for TRM installation is to prepare the ground surface, ensuring it is smooth to prevent rilling, followed by seeding and fertilizing, if required. Some manufacturers may recommend placing the mat first, then seeding directly into the mat, followed by spreading a one- or two-inch layer of topsoil over the mat and seed. After ground preparation, the TRM may be placed and anchored with stakes or staples. The manufacturer will provide specifications for the pattern and spacing of anchor stakes or staples, overlap between mats, and any additional product requirements. Installing the appropriate number of staples or stakes is important to prevent "tenting" of the material as the vegetation begins to grow and pushes up on the matting.

When the mat is placed first, followed by seeding and spreading a one- or two-inch layer of topsoil over the mat and seed, a secondary RECP should be placed over the TRM to protect the top layer of soil and seed until the vegetation can become established.

At the beginning of the installation, the product should be trenched in and anchored to prevent water from flowing under the matting. It is also recommended that additional staple barriers or trenches be installed at 25- to 35-foot intervals along the installation to cut off any flow that has developed under the matting and force the flow back on top of the matting.

Maintenance/inspection: Once installed, little maintenance needs to be done to TRMs. If the TRM is to be vegetated, the vegetation should be watered as needed. Until the vegetation is fully established, the ground surface should be inspected for signs of rill or gully erosion below the matting. If there are any signs of erosion, tearing of the matting, or areas where the matting is no longer anchored firmly to the ground, the matting should be repaired.

Design life: Permanent.

Estimated cost: Varies with the size and type of mat materials used in the design.